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A STUDY OF TASK LOADING USING A THREE MAN CREW ON A KC-135 AIRC--ETC(U)

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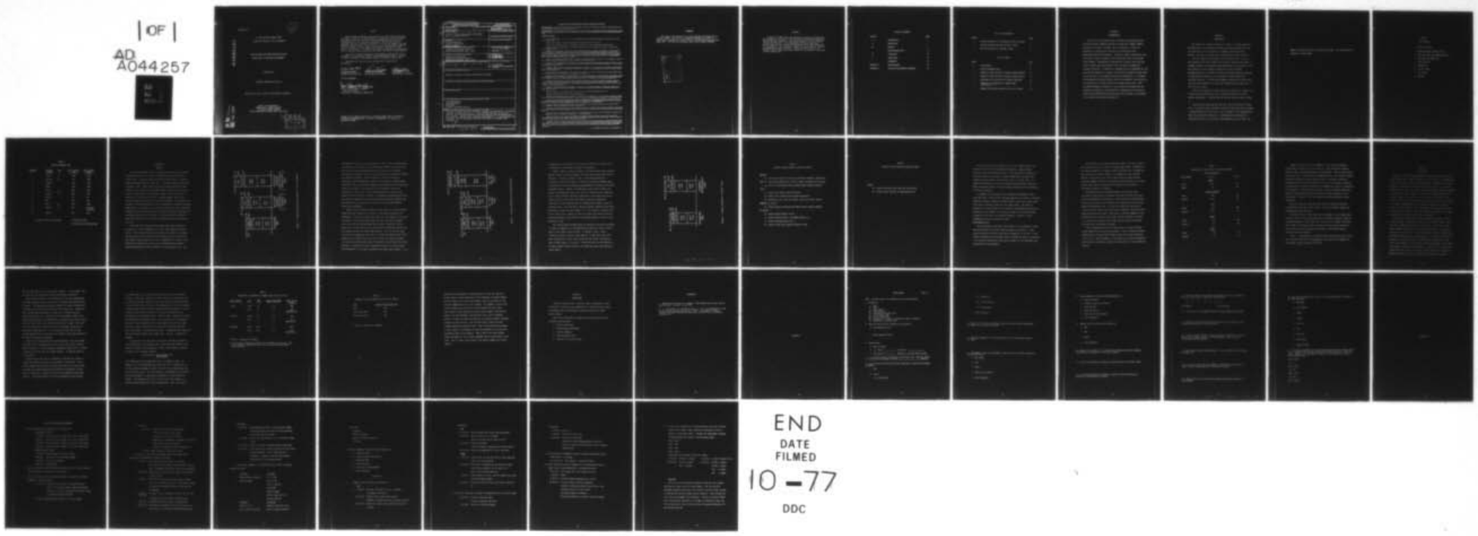

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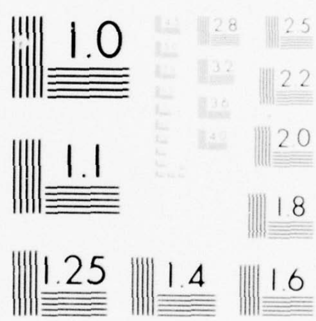


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# A STUDY OF TASK LOADING USING
# A THREE MAN CREW ON A KC-135 AIRCRAFT

CREW EQUIPMENT AND HUMAN FACTORS DIVISION

DIRECTORATE OF EQUIPMENT ENGINEERING

OCTOBER 1976

TECHNICAL REPORT ASD-TR-76-19

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A series of flight tests were conducted to assess the feasibility of reducing crew size on KC-135 from 4 to 3. A dual INS was installed in the test aircraft, and refueling missions flown task times of crew performing duties were recorded. Subjects also completed questionnaires. It was concluded that on several types of missions a three man crew leads to extremely high workloads.

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## FOREWORD

This report was prepared in the Crew Equipment and Human Factors Division (ENEC), Directorate of Equipment Engineering, Deputy for Engineering, Aeronautical Systems Division, Wright-Patterson Air Force Base, Ohio. The work was performed under Project Number ASDD0008.

## ABSTRACT

A series of flight tests was conducted to assess the feasibility of reducing the crew size on a KC-135 when a dual Inertial Navigation System (INS) was installed. Test crews consisted of pilot, copilot, and boom operator only. Crew performance during air refueling missions was assessed through questionnaires and inflight observation of crew members. Test missions included Cell, High Latitude, Coronet, and EWO/Mission Change scenarios. During critical phases of the missions, severe task overloading resulted in the deletion or deferral of many normal duties.

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## INTRODUCTION

As part of the continuing effort to reduce the operational costs of weapon systems, Commander-In-Chief, Strategic Air Command (CINSAC) directed that a series of flight tests be conducted to assess the feasibility of reducing the crew size on a KC-135 while still maintaining mission effectiveness. Instead of using a standard four man crew (pilot, copilot, navigator, and boom operator) the test program, "Giant Change", investigated the possibility of using a three man crew (pilot, copilot, and boom operator) with the copilot assuming the navigation function. In addition to changing the crew complement the crew stations were modified to include a dual inertial navigation system (INS) to aid the copilot in assuming his new duties (Reference 1). Personnel from Aeronautical Systems Division (ASD) were requested to participate in the flight test to provide support in the human factors area. This included performing an analysis of crew duties and providing data and observation relating to crew composition, workload, and crew activity. These data and observations reported herein are included as an addendum to the overall test report (Reference 1).

## SECTION II

## METHODOLOGY

The flight test program consisted of a series of flights considered representative of the spectrum of aerial refueling operations which are an integral part of the Strategic Air Command's (SAC) Operational Mission. The types of mission tasks investigated are shown in Table 1.

The test flights were conducted over a 120 day period. Prior to participation in the test program the three test crews had four hours of academic training on the operation and maintenance of the Carousel IV INS. The objective of this training, conducted by a Delco Training Representative, was to provide the crews with enough technical background to understand the operation of the Carousal IV INS and horizontal situation indicator. Following the academic training each of these three test crews was scheduled for a local INS familiarization flight prior to the first test flight.

Three test crews were initially used in the flight test; however, one of the crews was deleted after the first weeks testing due to other mission requirements. Personal data on the test crews are shown in Table 2.

Both objective and subjective data were collected during the flight test. The objective data consisted of crew task load data which was based on timed observations of the crew. Tape recordings of the communications were also collected and analyzed. A questionnaire was generated in conjunction with SAC test personnel and administered to the flight crew

members and safety observers following each flight. The questionnaire is Appendix I of this report.

TABLE 1

TEST PROGRAM

TYPES OF MISSIONS

1. MINIMUM INTERVAL TAKEOFF (MITO)
2. CELL (MORE THAN ONE TANKER REFUELING)
3. EMERGENCY WAR ORDER (EWO)
4. ALERT REACTION
5. PENETRATION
6. MISSION CHANGE
7. HI LATITUDE
8. CORONET

TABLE 2

SUBJECTS PERSONAL DATA

| SUBJECTS | AIRCREW POSITION | AGE | KC-135 FLYING TIME | TOTAL FLYING TIME |
|---|---|---|---|---|
| 1 | Pilot | 27 | 638 | 1328 |
| 2 | Copilot | 29 | 550 | 1200 |
| 3 | Copilot | | 260 | 1440 |
| 4 | M/NAV | | 2200 | 2600 |
| 5 | Pilot | 27 | 815 | 1023 |
| 6 | Copilot | 24 | 320 | 550 |
| 7 | Copilot | | 371 | 571 |
| 8 | NAV | | 120 | 290 |
| 9 | Pilot | 28 | 1160 | 1349 |
| 10 | Copilot | 27 | 612 | 815(1065 Civilian) |
| 11 | Copilot | | 550 | 780 |

Average of Pilot and Copilots 682 Hours (KC-135)

1044 Hours (Total Flying Time)

## SECTION III

## RESULTS

Of the eight different types of missions twelve sorties were flown. A detailed analysis of the copilot's workload was conducted on four sortie types: 1) mission change involving location change, 2) mission change requiring additional refueling, 3) Two High Latitude flights and 4) Coronet flight. These sortie types were selected because they were conducted over a portion of the program where there were few errors due to lack of experience with the system. Figure 1 shows the copilot's workload as a function of two types of mission change. Where only a location change was involved, one can see from Figure 1 that there was an increase of 17% task loading over that encountered in a standard refueling mission where no problems occur. The total task load of 115% constituted a moderate overload, did not appear to create any problems, and lasted for a relatively short period (10-15 min). On this particular flight the tanker was diverted to an alternate refueling track that was familiar to the crew.

The second, more complex mission change requiring an additional refueling on a track unfamiliar to the crew shows somewhat different results. This mission change was given while the tanker was refueling and resulted in a severe overload on the copilot as well as the pilot. This mission change required the pilot to determine the location of the additional refueling track, load in new coordinates and get Federal Aviation Administration (FAA) clearances to the refueling track. The

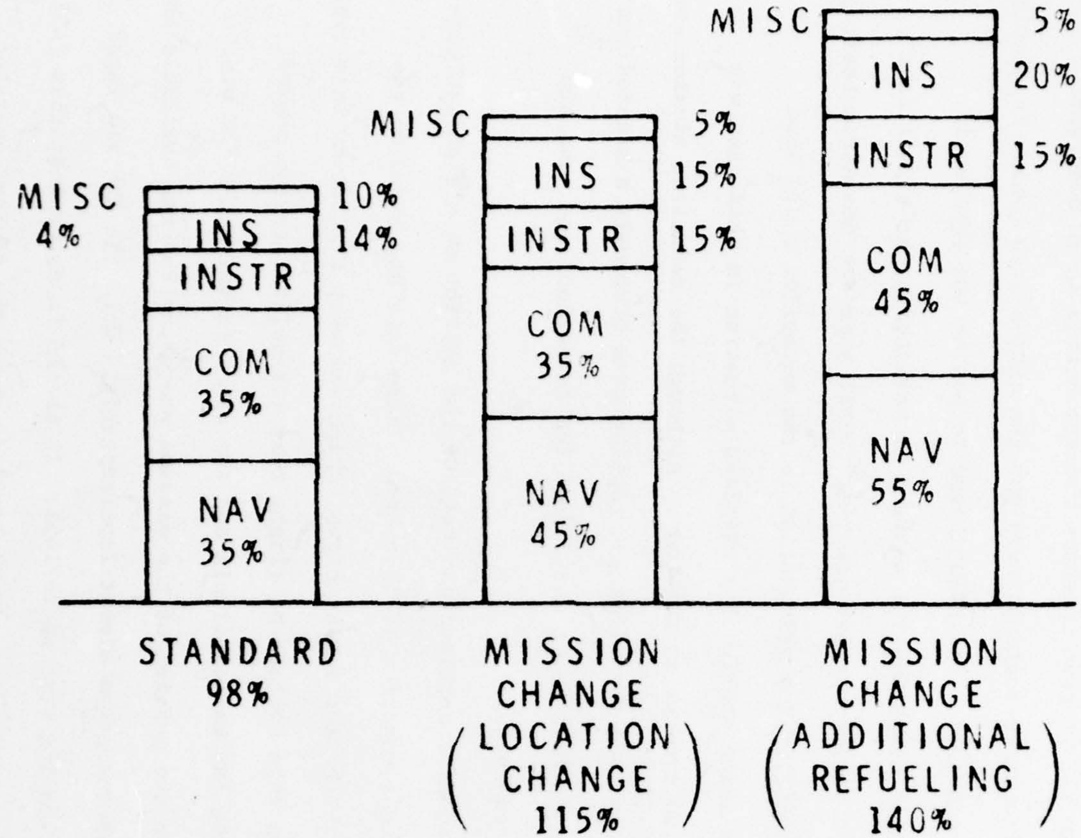


Figure 1. Copilots Workload as a Function of Type of Mission

requirements resulted in a total workload of 140%. While performing under this workload, the copilot selected the wrong refueling track, which was corrected by the SAC program director who was acting as an observer. Selecting the incorrect route in turn put the entire crew behind in meeting the rendezvous schedule. The pilot began to assist the copilot in navigating. While assisting the copilot in navigating, he significantly reduced his "out of the cockpit scanning" until approach the Air Refueling Contact Point (ARCP). Any malfunction in the autopilot would have resulted in a mission abort. The overload situation in this case was between 60 and 90 minutes in duration. Although the refueling mission was successfully completed the pilot and copilot were obviously exhausted and any malfunction at this point could have led to serious and possibly disastrous consequences.

Figure 2 shows a workload analysis of the copilot on a high latitude flight which had a duration of 12 hours. These data are based on the performance of both test flight crews, which was very similar on this type of mission. On this sortie the flight test was split into two phases: one in which the INS was available and the other in which the INS was taped over. On the portion of the mission where the INS was available the task loading increase was almost imperceptable. Once the INS was taped over the task loading went up to 145%. It should be noted that this 145% figure does not reflect the actual level at which the copilot operated. It reflects the workload that would be necessary to perform all the duties required. In essence the copilot performed little or no copilot duties but devoted most of his time to navigation and radar scope reading. It is

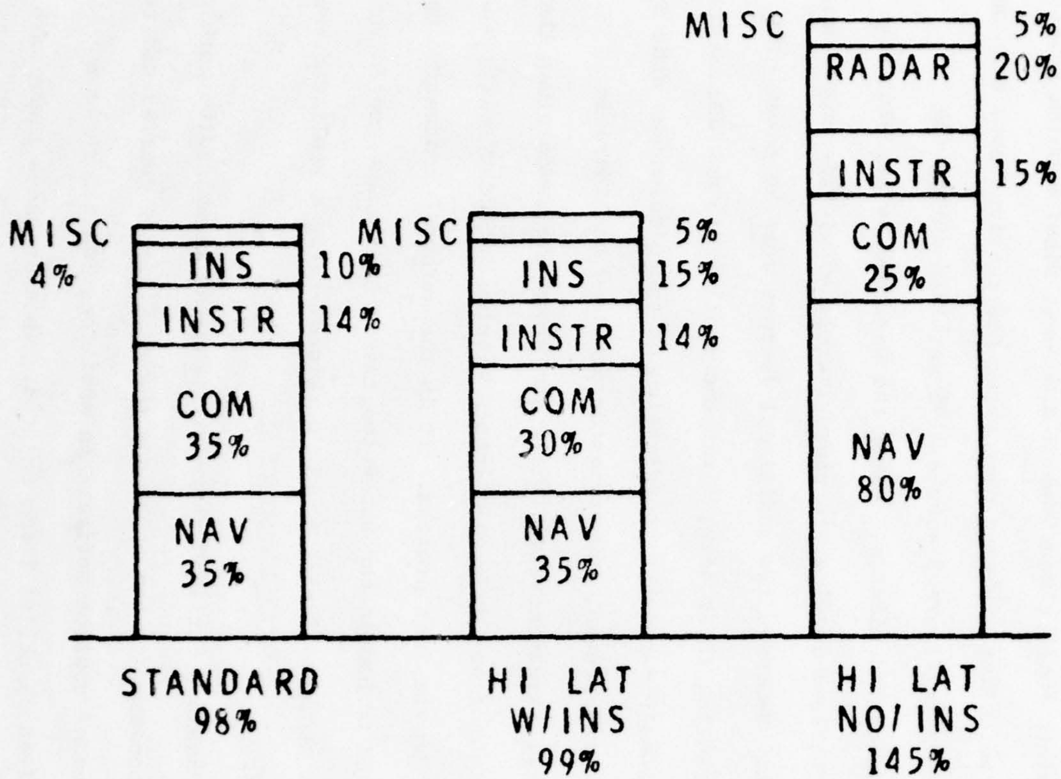


Figure 2. Copilots Workload on High Latitude Flight

recognized that the probability of losing both INS units is remote but it is nonetheless a possibility that must be considered.

Figure 3 depicts copilot workload on a Coronet mission which involves multiple tankers refueling fighters over water and requires more than one refueling. The data in Figure 3 show a 119% workload during the rendezvous portion of the mission. While the workload is somewhat high the duration of the task loading was approximately 40 minutes and is within reasonable limits. However, two additional factors must be taken into account in interpreting these data; first the copilot did not assume the entire workload possible because coordination of the mission was done by another aircraft, and second, the navigator provided considerable assistance in scope interpretation for thunderstorm avoidance along the refueling route. This was done to maintain mission integrity which always had priority during the test program. It is the authors' contention that if the copilot had to handle the above two tasks; then these two factors would have added at least 10-12% to his workload making a realistic total workload of 130%.

The three missions outlined above all resulted in excessive workloads. In order to compensate for the workloads the copilots in general omitted many of their normal copilot duties. In addition, Table 3 shows a listing of required checklist items omitted. In many cases these were minor omissions but several items could have had serious consequences. These include items B, D, H, and J. There were also two items missed by the pilot during the test (Table 4) but these were minor and would have little impact.

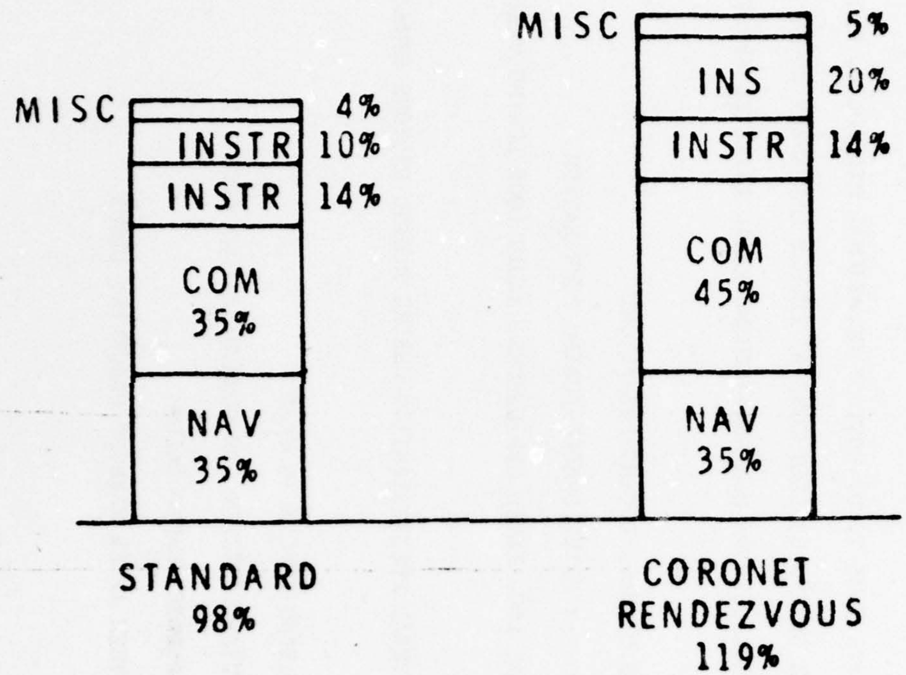


Figure 3. Copilots Workload on "Coronet" Flight

TABLE 3

CHECKLIST ITEMS OMITTED ON VARIOUS FLIGHTS

COPILOT:

(A) DID NOT HAVE TIME TO DO MOST OF OCCASIONAL HYDRAULIC, ELECTRICAL FUEL, 02, AND ENGINE CHECKS USUALLY DONE AT LEVELS OFF EVERY 20-30 MINUTES.

(B) DID NOT LOOK OUTSIDE DURING AIRBORNE RADAR DIRECTED APPROACH (ARDA)

(C) MISSED RADIO CHECK DURING PRE-FLIGHT

(D) MISSED TWO ALTIMETER CHECKS DURING PENETRATION

(E) MISSED FUEL LOG, LEVEL OFF CHECKS, RADIO LOGS DURING VARIOUS SEGMENTS OF FLIGHTS

(F) MISSED SEVERAL PRESSURIZATION CHECKS DURING VARIOUS SEGMENTS OF MISSION

(H) FORGOT HEADING CHECKS IN GRID

(I) MISSED SEVERAL ENTRIES ON COMMUNICATIONS LOG

(J) OMITTED REQUIRED RADIO CALLS

(K) OMITTED OTHER AFTER TAKEOFF CHECKLIST ITEMS

TABLE 4

CHECKLIST ITEMS OMITTED ON VARIOUS FLIGHTS

PILOT:

(A) CALLED FOR ENGINE START CHECK BUT DID NOT WAIT

(B) MISSED SEVERAL ENTRIES ON COMMUNICATIONS LOG

Three items that have an impact on crew task loading that were not observed during the test program were emergencies, coding decoding operations, and safe passage procedures. Any emergencies encountered in the polar flights and the mission change (additional refueling) would probably have resulted in a mission abort with a three man crew. The additional workload in the case of coding-decoding operations would probably be relatively minor. The safe passage procedures will be addressed by SAC test personnel.

In summary, in the context of the scenarios investigated, using a three man crew to cover the SAC refueling operation will result in excessive workloads leading to omission of normal copilot duties that in many cases could lead to hazardous conditions for flight safety. The specific probability of these leading to an accident is problematical and cannot be addressed with any degree of reliability; however, we do know that many accidents are the result of omissions leading to a series of events culminating in loss of aircraft and crews.

QUESTIONNAIRE DATA

The questionnaire form used in this study is in the Appendix I, while detailed responses to specific questions appear in Appendix II. Both crews had initial difficulty inserting data waypoints in the INS. As the flights progressed these problems ceased. Although the basics of operation of the INS were mastered the crews did not master all the refinements and capabilities of the equipment.

The copilots of both crews operated the radar. The pilot of one of the crews did assist the copilot in reading some returns. Operation of the radar throughout Giant Change testing continued to be a problem and more training is evidently needed. The comments by crews included: failure to anticipate target changes during Airborne Radar Directed Approached (ARDA); difficulty in picking up ground references on a polar flight; difficulty in reading radar in daylight; and inability to discriminate severity of weather.

When questioned about performing normal flying duties while concurrently performing the navigation functions the pilots (a/c) and copilots responded quite differently. While both pilots indicated that there was an increase in task loading, they stated that the crew could handle the additional tasks. The copilots stated that they were on occasion heavily loaded, copilot duties were neglected, and some copilot monitoring checks were missed. When asked to identify segments of the missions where an overload occurred the copilots responded as follows: T.O. climb, prior rendezvous (Rz), ARDA, mission change, during high latitude flight, and weather avoidance.

Table 5 summarizes percent of time devoted to various functions during rendezvous for the pilot and copilot. The two copilots differed significantly in the mean time looking outside the aircraft during Rz (1.25% vs 21). This divergence is attributed to one pilot performing the radar function, allowing his copilot the opportunity to look outside the aircraft.

TABLE 5

PERCENTAGE OF TIME DEVOTED TO VARIOUS FUNCTIONS

DURING RENDEZVOUS

| CREW NUMBER | (R 122) | (E 121) |
|---|---|---|
| | RADAR | |
| PILOT | 1.25% | 20% |
| COPILOT | 76% | 64% |
| | OUTSIDE AIRCRAFT | |
| PILOT | 28% | 26% |
| COPILOT | 1.25% | 21% |
| | INS | |
| PILOT | 46% | 30% |
| COPILOT | 1.25% | 5% |
| | RADIO | |
| PILOT | 16% | 20% |
| COPILOT | 15% | 6% |
| | OTHER | |
| PILOT | 8% | 4% |
| COPILOT | 5% | 4% |

Comments on the location and readability of the special navigation system added to the KC-135 for this study e.g., INS, Horizontal Situation Indicator (HSI), and radar generally were unfavorable. This was particularly true in the case of the HSI, which was admittedly in a poor location, causing parallax problems and blocking operator vision. Deficiencies mentioned regarding location of the INS were that it was not in the normal crosscheck, was susceptible to glare, and difficult to program with respect to orientation of the operator. Positioning of the radar scope was considered undesirable because it required both pilots to turn and look down requiring a lot of bending over. Location of the radar controls was also mentioned as being undesirable.

When the crews were asked what areas they felt required additional training they cited radar in most cases. Practice in mission changes and navigating were also mentioned.

The question "Do you feel there were any segments of the mission where safety of flight could be jeopardized due to increased workload?" evoked the following responses: "Very rarely did I look out of the "ARDA's" aircraft", and "changes in workload detract from several areas--clearing outside for other traffic and monitoring engine performance, monitoring hydraulic, electronic and fuel systems".

Finally, crew estimates of increased cockpit time required with a three man crew varied from 20% to 90% depending on the mission (See Appendix II). The average increase estimated was 40-50%.

## SECTION IV

## DISCUSSION

Results of this test program definitely indicate that task overloads on the copilot and, in some cases the pilot, are going to occur when using a three man crew on an aerial refueling mission. Depending on the type of mission and circumstances this overload will vary from 117% for a minor mission change to 145% for a major change involving more complex procedures or failure of the INS. A pilot can handle task loadings above 100% in a variety of ways: He can work faster; he can omit some required tasks; he can have another crew member assume some tasks; or various combinations of the three. Working faster is an acceptable solution providing the effort is of short duration (up to 30 minutes) and the task overloading is on the order of 20-25%. When these figures are exceeded, errors begin occurring and/or critical tasks begin to be omitted.

In the "Giant Change" test program overloads were generally handled by omitting tasks or depending on the pilot to accomplish tasks. These were mostly communications tasks or radar tasks. In the case of major mission changes both pilot and copilot were overloaded. A second major observation is that we are, in fact, eliminating the copilot rather than the navigator when we go to a three man crew. In order to accomplish the navigation function the copilot is in many cases omitting his copilot duties and is generally not available to make the instrument cross-checks now required according to SAC procedures. In this vein the authors also observed that the concept of "see and be seen" suffered on a majority of missions because the copilot was attending to navigation functions.

This was particularly true during mission changes. It would appear that the three man crew considerably reduces operational flexibility.

Since mission integrity took precedence over the test program there were many instances in which the copilot did request assistance from the navigator. This assistance was mainly required for radar interpretation of weather returns and trouble shooting radar malfunctions. Apparently more training and/or experience on radar will be required than was obtained during the test. During the test the preflight checks on the navigational equipment were performed by the navigator and copilot, which would not be the case in an operational situation. However, this could be easily overcome by starting the copilot's preflight check earlier when using a three man crew. It also should be noted that the task loading figures cited in this report are probably conservative because of the mission integrity requirements.

Based on the questionnaire data and observations of the crew during the flight test a reconfiguration of the pilot's and copilot's station appears warranted. A more integrated configuration would lead to a better crosscheck and reduce the task loading somewhat. An improved radar is also desirable.

Another factor that must be considered in requiring the copilot to assume the navigation function is the problem of proficiency. If the copilot assumes this function he may have less time to fly the aircraft and learn those tasks associated with piloting, alternatively, he may devote so much time to flying duties that his navigational proficiency suffers. A situation similar to this was encountered by the Tactical

Air Command when F-4 pilots were acting as both copilots and systems operators. There was a tendency for these operators to concentrate more on flying than systems operation. When a systems operator was stationed in the rear seat better proficiency was demonstrated. SAC could encounter a similar situation with copilots assuming navigation functions. Closely associated with the above problem is the issue of experience level encountered in SAC operations today. Table 6 shows a comparison of tanker crew experience in 1968 versus 1975. One can readily see a substantial reduction in the experience level of crews today versus those of eight years ago. Table 7 shows the 12-1/2 year point in service time when pilots transition to a nonflying job status. A commercial pilot using the INS has an average flying time of 9000 hours. (Source: Strategic Air Command).

A final issue to be discussed is the entire problems of measuring crew task loading. The procedure used in this study was similar to that used in an earlier study, (Reference 2) where task loading was figured according to the following formula:

$$\text{Crew Workload} = \frac{\text{time required}}{\text{time available}} \times 100.$$

This formula gives the average time unit to accomplish a task. For example, a 77% crew workloading would mean that for 77 minutes out of a 100 minute mission segment an operator would be busy accomplishing some required task or tasks. The time available is determined by the mission, aircraft performance or operational environment, or some combination thereof. This measures what could be called overt task loading, i.e., directly observed behavior or task accomplishment. While this type of

TABLE 6

COMPARISON OF EXPERIENCE IN TANKER CREWS (1968 VS 1975)*

| CREW POSITION | YEAR | AGE** | COMBAT CREW YEARS | TOTAL FLYING TIME |
|---|---|---|---|---|
| PILOT | 1968 | 35 | 7.6 | 3585 |
| | 1975 | 29 | 4.1 | 1889 (1082 KC-135) |
| CO-PILOT | 1968 | 26.7 | 2.3 | 964 |
| | 1975 | 26 | 2.1 | 677 (385 KC-135) |
| NAVIGATOR | 1968 | 30.8 | 5.4 | 2500 |
| | 1975 | 29.0 | 3.7 | 1710 (985 KC-135) |

* Source: Strategic Air Command

** It is policy to assign and retain all crew members to one crew. This column compares differences across years and crew positions (Note Pilot position)

TABLE 7

AVERAGE TOTAL FLYING HOURS IN SAC (12-1/2 YEARS)*

| YEAR | AVERAGE TOTAL FLYING TIME |
|---|---|
| 1968 | 3500 |
| 1976 (projected) | 2000 |
| Future (projected) | 1700 |

* Source: Strategic Air Command

measure has the advantage of being objective, it does not take into account stress or task loading due to the pressures of decision making. This the authors call covert task loading. Many of the duties of the aircraft commander fall into this category. For example, in one of the Coronet missions the pilot had to concern himself with the proper functioning of normal engine start and aircraft checkout, snow and ice removal, crew and equipment, plus meeting a block time in marginal weather. During the flight decisions had to be made on weather avoidance, rerouting to meet receivers, and the monitoring of copilot who had assummed additional navigation tasks. None of these decision processes or their effects on performance is directly measurable in the way other psychomotor tasks can be measured. Hence, many of the task loading figures estimated for the aircraft commander must be interpreted in this light. This of course varies greatly with mission segment and circumstances.

## SECTION V

## CONCLUSIONS

This test indicated that on several types of operational refueling missions a three man crew composition on a KC-135A aircraft leads to extremely high crew workloads, resulting in deletion of many copilot duties.

Other factors pertinent to using a three man crew include the following considerations:

a. Copilot proficiency

b. Crosstraining requirements

c. Cockpit redesign

d. Crew experience level

e. Concept of "see and be seen"

## REFERENCES

1. Headquarters Strategic Air Command, "GIANT CHANGE final report, KC-135 Dual INS test." Hq SAC, 15 July 1976.

2. R. J. Schiffler, R. Geiselhart, and L. J. Ivey, "Crew Composition Study for an Advanced Tanker/Cargo Aircraft (ATCA).", Aeronautical System Division, Equipment Engineering Directorate, *ASD-TR-76-20 (In printing)*, October 1976.

APPENDIX I

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NOTE: Asterisk items to be completed only on first mission.

1. Background

a. Name:
*b. Age:
c. Crew Number:
*d. Crew Position:
*e. Aeronautical Ratings held:
*f. Total Flying Time:
*g. KC-135 Flying Time:
*h. Experience in present crew position (Years & Months):
*i. Experience on present crew:

2. Have you had any prior experience in the use of:

a. INS (Explain Fully)?

b. Radar (Explain Fully)?

3. Mission Data.

a. Date of Flight

b. T.O. Time Z ____________ Lnd Time Z ____________________

c. This was my # ___________ mission in the dual PINS aircraft.

d. Briefly explain the mission profile flown (eg., Alert ST, MITO, #2 in CELL position change, A/R with ________________________ ACFT etc).

4. Did you have any difficulties while operating or using the following equipment?

a. INS:

b. Radar:

(1) Positioning

(2) Rendezvous:

(3) Station Keeping:

(4) WX Avoidance:

c. Other (Explain):

5. How do you feel about performing normal pilot duties while concurrently performing the navigation functions?

6. Were there segments of the mission where you felt overloaded (pressed for time)?

7. Instruments. Rate the instruments listed below in the overall importance during this mission.

a. HSI (PINS):

b. INS:

c. Radar:

d. Doppler (GS & Drift):

e. Other (Explain):

8. During rendezvous, how much time was devoted to:

a. Using the radar?

b. Looking outside the aircraft?

c. Using the INS?

d. Using the radio?

e. Using other aids/equipment?

f. Other (Explain)?

9. Comment on the location and visibility of:

a. INS:

b. HSI:

c. Radar:

d. Other (Explain)

10. Based on the results of this mission what additional mission planning items would you accomplish for your next mission?

11. Do you feel additional training is desirable and if so-in what areas?

12. Do you feel the INS would improve procedures during refueling and recovery on an EWO mission? Explain.

13. Given the present system (INS) and displays, rate how confident you would be in successfully completing an EWO mission.

| --- | --- | --- | --- | --- | --- | --- |
|---|---|---|---|---|---|---|
| 7 | 6 | 5 | 4 | 3 | 2 | 1 |

Very unsure                                        Very confident

14. Do you have any recommended checklist changes/additions/deletions?

15. Would the INS provide additional safety factor for penetration and landing with external Nav aids available?

16. Was any weather avoidance necessary during this mission? If so, how did it affect pacing, workload, crew coordination? Were you able to effectively avoid the weather.

17. Were control times revised inflight? If so, how did it affect pacing, workloads ect?

18. Do you feel there were any segments of the mission where safety of flight could be jeopardized due to increased workloads?

19. What would do if your INS system malfunctioned during overwater or polar flight?

20. Was there any degradation in any of the following areas as a result of increased workloads?

a. Preflight:

b. Taxi Takeoff:

c. Climb:

d. Cruise:

e. Pre A/R:

f. A/R:

g. Post A/R:

h. Penetration:

i. Approach phase:

21. It has been essumed that increased workloads would also increase "head in the cockpit" time, therefore decreasing the pilots ability to "see be seen". Estimate the approximate increase in time required as a result of the increased tasks.

(5% or less)

5 - 9

(10% - 20%)

41 - 29

(30% - 40%)

41 - 49

(50% - more)

APPENDIX II

## SELECTED QUESTIONNAIRE RESPONSES

2. Have you had any prior experience in the use of:*

   a. INS (Explain fully)?

      P (E-121) - Initial practice flight (3 hr local) w/dual PINS.

      CP(E-121) - Initial practice flight (3 hr local) w/dual PINS.

      P (R-122) - Initial practice flight (3 hr local) w/dual PINS.

      CP(R-122) - Initial practice flight (3 hr local) w/dual PINS.

   b. RADAR (Explain fully)?

      P (E-122) - Radar fixing in EC-47's in S.E.A.

      CP(E-121) - 500 hours C-47 with weather RADAR.

      P (R-122) - Only station keeping

      CP(R-122) - No experience

The two copilots received informal instruction on use of radar from unit staff and from the navigators on their crews.

4. Did you have any difficulties while operating or using the following equipment: (INS Radar Other).

   CP (E-121) - Could not pick up FB-111 transponder beacon
   Failed to anticipate target changes during ARDA
   Difficult to pick up good ground references during
   Hi Latitude (reverse returns).

* Item #3 completed after flight #1 in "Giant Change".

(continued)

CP (R-122) - Difficult to read radar in daylight

Difficult to pick up B-52 beacon

Difficult to pick up F-111 beacon

Remembering to compensate for magnetic variations

Polar returns hard to interpret

Difficult to determine weather encountered

P (R-122) - Had trouble with radar due to glare

5. How do you feel about performing normal pilot duties while concurrently performing the navigation functions?

P (R-122) - With added effort isn't much of a problem.

By placing INS, HSI, RADAR in more visible locations pilot's instrument cross check could vastly improved.

CP (R-122) - Keeps you busy--initially you tend to forget about flying aircraft

P (R-122) - Difficult when given an inflight mission change.

With a lot of work can be done. Makes things rushed at times when running checklists concurrent with navigating.

P (R-122) (Hi lat) - It takes a lot of time when you don't have the INS.

It doesn't leave much time for other duties.

P (E-121) - We worked harder but within our capabilities

CP (E-121) - Two pilots can perform it but only at the cost of some quality of performance (piloting/navigating)

(continued)

CP (E-121) - Reprogramming the PINS or other mission changes requiring extended work detracts from performing normal (KC-135) pilot duties

P (E-121) - More we use PINS easier it is to incorporate added duties

CP (E-121) - Unable to monitor airspeed/attitude during ARDA

CP (E-121) - For as many pilot (copilot) duties that I was doing during navigation - leg to ARCP and back to Frobisher - I might as well have been working comfortably at the navigation table.

6. Were there segments of the mission where you felt overloaded (pressed for time)?

| P (R-122) | CP (R-122) |
|---|---|
| Rushed during preflight | T.O., Climb |
| Mission change | Prior to RZ |
| | Prior to descent |
| | Doing ARDA |
| | Mission change |
| | Entire flight (Hi lat.) |
| | During refueling |
| P (E-121) | CP (E-121) |
| Prior to A./R. | Halfway to ARCP (Hi lat.) |
| Rush to get in #22 mode | Need to readjust position |

(continued)

P (E-121)

Weather avoidance

When A.R. checks and RZ were

occurring

8. During rendezvous, how much time was devoted to:

   a. Using the radar?

   b. Looking outside the aircraft?

   c. Using the INS?

   d. Using the radio?

   e. Using other aird/equipment?

   f. Other (Explain)?

See Table 5

9. Comment on the location and visibility of:

INS

a. P (R-122) - One must look down to see it. Degrades instrument cross-check

CP (R-122) - Would be better under glare shield
Awkward to program and read in present location

CP (E-122) - Should be oriented vertically with respect to operator

(continued)

HSI

b. P (R-122) - Blocks outside view, glare from sun problem

CP (R-122) - Have to look at it at an angle

Needs to be lower and in front of pilot

P (R-122) - Parallax problems

Ideally should be integrated with FD-109 (R-122)

CP (E-121) - Should be perpendicular to pilot (CP-E-121)

RADAR

c. P (R-122) - Copilot must turn and look down to take fixes and reach to talk on intercom

CP (R-122) - Great deal of bending over and trying to shade scope from sun needs to be in front of CP

Hard to read during bright day

P (E-121) - Scope useless to pilot, controls should be up front and scope mounted higher

CP (E-121) - Should be located so pilot and copilot could see it

11. Do you feel additional training is desirable and if so--in what areas?

CP (R-122) - Practice using the radar

Practice navigating and radar

P (R-122) - Practice in mission changes

(continued)

P (R-122) - More A.R.

P (E-121) - Practice in radar & Rz

CP (E-121) - Practice in radar ARDA

Practice in Rz and problems which could occur

Without a navigator need training in use of doppler, celestial nav

14. Do you have any recommended checklist changes/additions/deletions?

Crew (R-122) - No changes

P & CP (E-121) - Add item #55, turn Off HF radio

18. Do you feel there were any segments of the mission where safety of flight could be jeopardized due to increased workloads?

CP (R-122) - Very rarely did I look outside aircraft

P (R-122) - ARDA's

P (E-121) - Possibly during penetration A.R. and Rz

CP (E-121) - Rz and CP doing a difficult maneuver

Changes in workloading detract from several areas

Clearing outside for other traffic

Monitoring engine performance

Monitoring hydraulic, electronic and fuel systems

21. It has been assumed that increased workloads would also increase "head in the cockpit" time, therefore decreasing the pilot's ability to "see and be seen". Estimate the approximate increase in time required as a result of the increased tasks.

(5% or less)

(10% - 20%)

(30% - 40%)

(50% - more)

Useful data was obtained on five (5) flights

| | |
|---|---|
| P (R-122) - 10-20% (5) flights | P (E-121) - 10-20% 3 flights 5%-(2) |
| CP (R-122) - 30-40% 2 flights | CP (E-121) - 10-20% 1 flights |
| 50% - 3 flights | 30-40% 1 flights |
| | 50% 2 flights |
| | 90% 1 flights |

Workload

Two of the critical mission evaluated during this test program were mission change and Hi Latitude flights. With the copilots assumming navigation functions, both copilots reported 30-40% increase in workload when mission change task was required. This increase was for a short time segment (30-40 minutes). During hi latitude flights where copilots were required to do a number of navigation tasks, and for a long period of time (2 hours or more) increased workloads of 50 and 90% were reported.